# Engineering Note for

# E-906 Tube Assembly

Project:  E906, P-25 (LANL)

Title:  E-906

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**ABSTRACT:**

The following calculation note pertains to the E-906 Prop Tube Assembly, as developed by Ming Liu and Walt Sondheim.  These calculations describe the ability of the Tube Assembly to handle service and handling loads.

**DESIGN:**

Two rows of tubes are nested one on top of the other, but staggered.  A bead of glue is placed longitudinally at the tube to tube interface.  This glue will provide additional structural support, but it will not be taken credit for in the structural analysis for simplicity.  Additionally, uncertainties regarding the strength of the glue and its ability to adhere to the aluminum tube make it difficult to include in the analysis.

0.00          30.00          60.00 (in)
       15.00          45.00
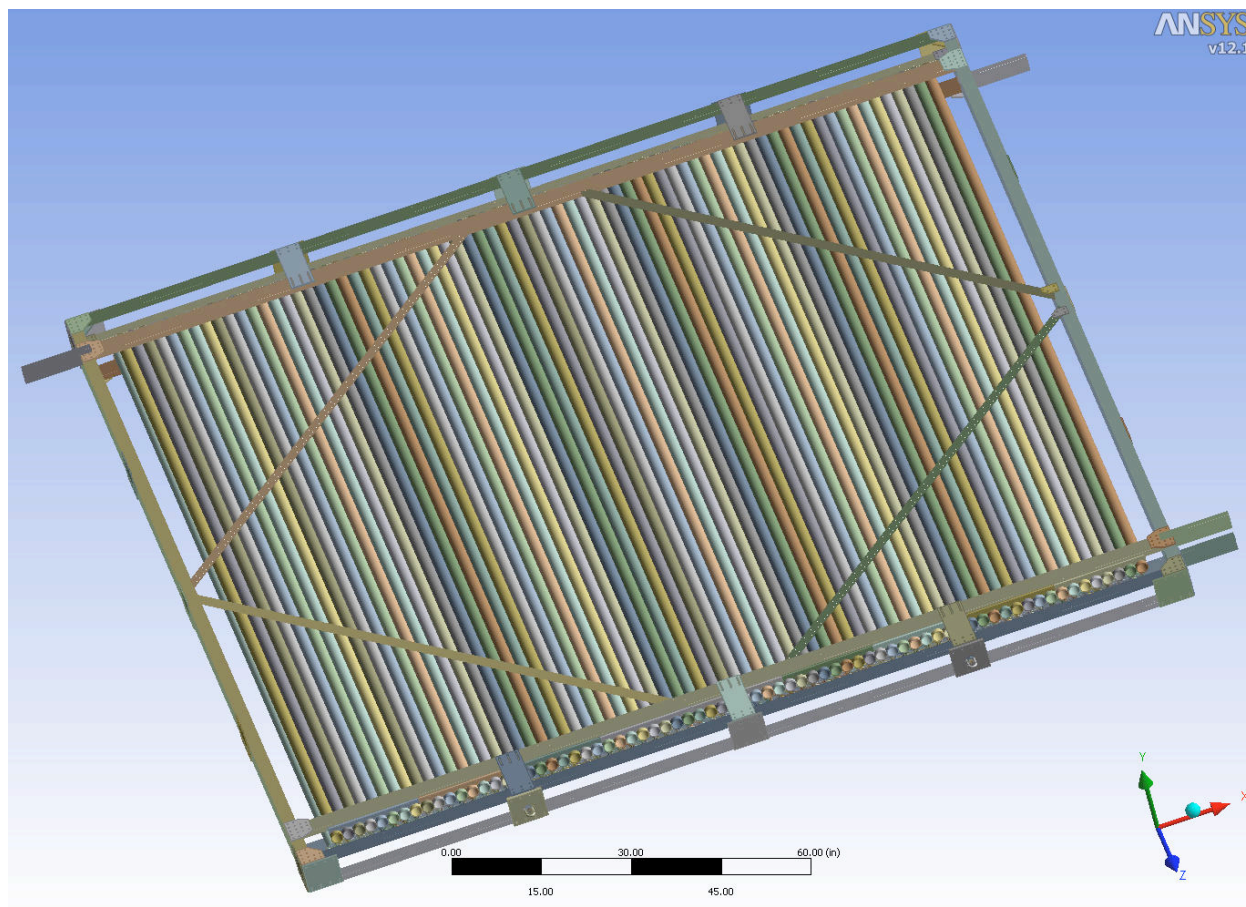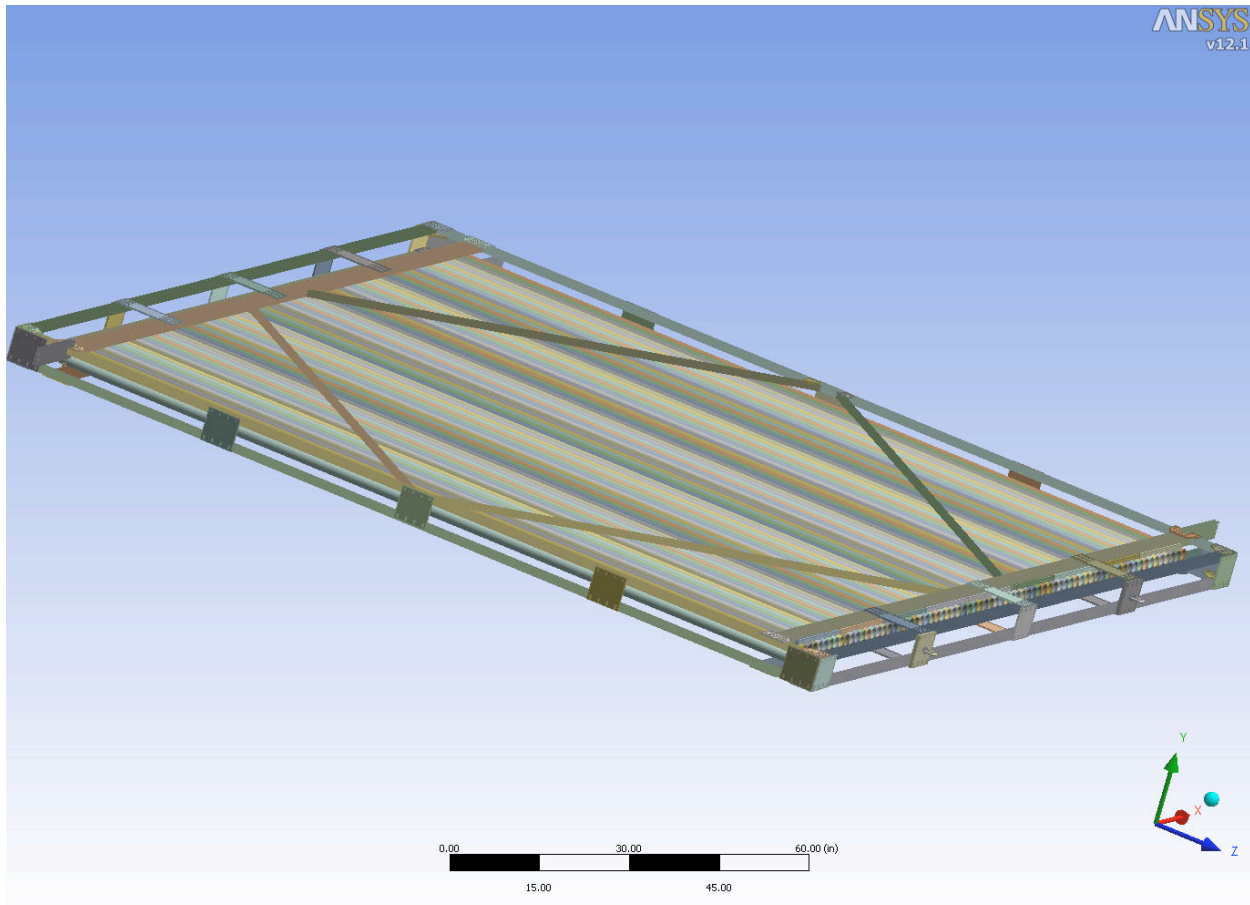
**ANALYSIS:**

Refer to the Appendix in "Mechanical Engineering Design", 4th Edition, Shigley and Mitchell, for maximum moment, stress, and deflection formulas. Refer to Appendix C, "Mechanics of Materials", Second Edition, Gere and Timoshenko for formula and explanation of the parallel axis theorem.

The frame is composed primarily of 80/20 Inc. brand extruded aluminum beams. Plates used to join the 80/20 Inc. beams are also produced by 80/20 Inc.

Aluminum allowable stresses are obtained from the Aluminum Design Manual published by the Aluminum Association. Part I-A, Table 3.3-1 lists the 6061-T6 minimum tensile ultimate stress as 38 ksi, and the minimum tensile yield stress as 35 ksi. Part I-A, Section 1.3 describes safety factors to be applied. Bridge type structure safety factors are used. The allowable tensile stress is the lesser of the minimum yield strength divided by a factor of safety of 1.65, or the minimum ultimate tensile strength divided by a factor of safety of 1.95. Thus, an allowable tensile stress of 19,487 ksi shall be used herein.

The allowable shear stress is calculated using the Aluminum Design Manual Part 1-A, Section 3.4.20, where $F_s=(F_{ty}/1.732)/n_y$. The value for $n_y$ is obtained from Table 3.4-1 and is 1.65. The allowable shear stress is then 12,247 psi.

Part I-A Table 3.3-1 lists the minimum compressive yield as 24 ksi.

1010, 1020, and 1030 members are made from 6105-T5. The Aluminum Design Manual Part 1-A, Table 3.3-1 lists the 6105-T5 minimum tensile ultimate stress as 38 ksi, and the minimum tensile yield stress as 35 ksi. Part I-A, Section 1.3 describes safety factors to be applied. Bridge type structure safety factors are used. The allowable tensile stress is the lesser of the minimum yield strength divided by a factor of safety of 1.65, or the minimum ultimate tensile strength divided by a factor of safety of 1.95. Thus, an allowable tensile stress of 19,487 ksi shall be used herein.

The 80/20 Inc. joining plates are also made from 6105-T5 material. Accordingly, the allowable tensile stress for these parts is also 19,487 psi. The allowable shear stress is calculated using the Aluminum Design Manual Part 1-A, Section 3.4.20, where $F_s=(F_{ty}/1.732)/n_y$. The value for $n_y$ is obtained from Table 3.4-1 and is 1.65. The allowable shear stress is then 12,247 psi.


The AISC Manual of Steel Construction is used to determine allowable tensile and shear stress for the fasteners. The allowable tensile stress is taken as 1/3 of the minimum ultimate tensile stress. The allowable shear stress is taken as 0.17 times the minimum ultimate tensile strength, when threads are included in the shear plane. The fasteners used for the frame construction are Alloy 4037 quenched and tempered steel according to the manufacturer. The ultimate tensile strength of this material is 101,000 psi. Consequently, the allowable tensile stress is 33,650 psi. The allowable shear stress is 17,170 psi.


**Calculation # 1**

Analyze the one tube alone to determine if it can support its own weight, simply supported at the ends.

Calculate weight of tube,

$d_{outer}$ = 2.00 in.

$d_{inner}$= 1.93 in.

$t_{tube\ wall}$ = 0.035 in.

$Weight_{single\ tube}$ = (cross sectional area)(length)(density)

$Area_{tube\ cross\ section}= \pi\ [(1.0\ \text{in.})^2 - (0.965\ \text{in.})^2] = 0.2161\ \text{in.}^2$

$Density_{aluminum}$ = 0.1 lb/in.$^3$

Length = 144 in.

Weight$_{single\ tube}$ = 3.11 lb

Weight$_{single\ tube}$/length= 0.0216 lb/in

$I_{single\ tube}$ = π [(d$_{outer}$)$^4$ − (d$_{inner}$)$^4$] / 64 = 0.1043 in.$^4$

Maximum moment for a simply supported beam with a distributed load is

M$_{max}$ = (w l$^2$)/8 = 56 in-lb

w = 3.11 lb/144 in. = 0.0216 lb/in.

l = length = 144 in.

σ$_{max}$ = M c/I = (56 in-lb)(1.00 in.)/0.1043 in.$^4$ = 537 psi

c = tube radius  = 1.00 in.

δ$_{max}$ = (5wl$^4$)/(384EI) = 0.12 in.

E$_{aluminum}$ = 10,000,000 psi

Tubes are aluminum 6061-T6.  The calculated stress is well below the 19,487 psi allowable tensile stress and is therefore acceptable.  Deflection is small.  Stress is also low enough so that local tube wall buckling should not be a concern.  Glued joints not taken credit for, and ends are clamped by the scalloped pieces.  Thus, tubes individually are acceptable.
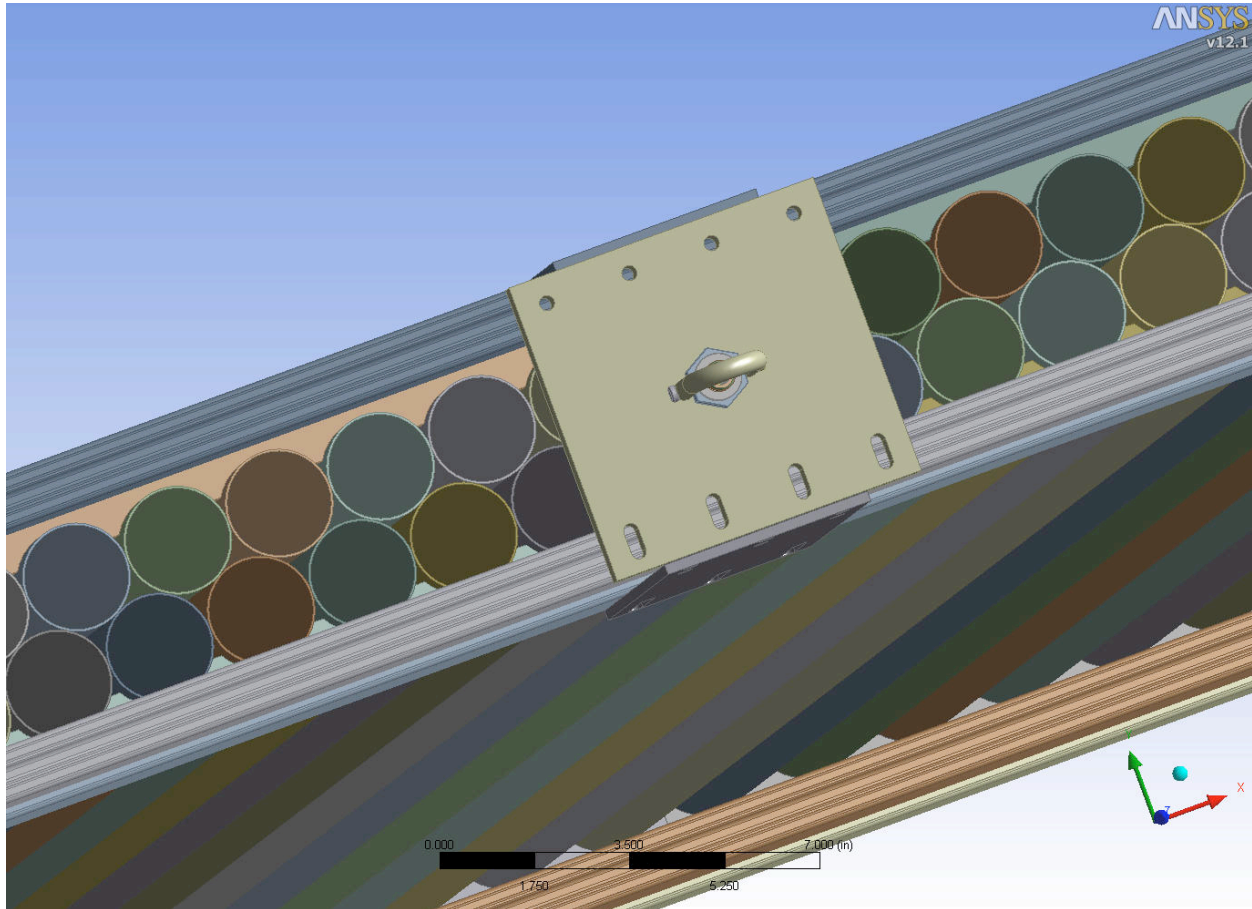
**Calculation # 2**

Calculate weight of tube array.  Each tube weighs 3.11 lb, and there are 144 tubes.  Thus total tube weight is 450 lb.  Add 10% for glue.  For analysis purposes, use:

Weight$_{tube\ array}$ = (450 lb)1.1 = 495 lb

Weight of the structural members must be considered.  Use a total weight (tubes and structural frame) of 700 lb.

**Calculation # 3 – Lifting Features**



<u>Frame in vertical position  (tube axes perpendicular to floor)</u>

A lifting plate and swivel hoist ring will be used at each corner.  The plate will be 5/8 inch thick and made from 6061-T6.  A Carr-Lane swivel hoist ring (CL-1000-SHR-1) with a 1000 lb capacity will be mounted to the plate.  The swivel hoist ring bolt is 0.54 inches long, and the plate is 0.625 inches thick, so sufficient engagement exists.  Calculate thread shear stress in the mounting plate (frame in upright position).

$A_{\text{shear, 5/8" threads in the hoist ring mounting plate}}$ = π(5/8 in.)(0.625 in.)(1/2) = 0.61 in.$^2$

$\tau = V/A_{5/8\text{'' threads in the hoist ring mounting plate}} = (1000 \text{ lb})/0.61 \text{ in.}^2 = 1,640 \text{ psi}$

The allowable shear stress of 6061-T6 is 12,247 psi. Shear stress calculated above is acceptable.

Check tensile strength of eight fasteners which secure the plate to the frame. Use actual load of 350 lb (700 lb frame weight divided amongst two hoist rings).

$A_{\text{tensile, 1/4'' screw}} = 0.0318 \text{ in.}^2$

$\sigma_{0.25\text{''hoist ring plate screws}} = F/A = 350 \text{ lb}/(8(0.0318 \text{ in.}^2)) = 1,376 \text{ psi}$

The allowable tensile stress for the fasteners is 33,650 psi. Also, refer to Calculation #9 below.

Frame in horizontal position (tube axes parallel to floor)

The plate is secured to the frame with eight 0.25 inch diameter screws. Check shear strength of screws.

$A_{\text{shear, 1/4'' screw}} = 0.0269 \text{ in.}^2$

$\tau = V/A_{\text{shear, eight 1/4'' screw}} = (350 \text{ lb})/(8(0.0269 \text{ in.}^2)) = 1,626 \text{ psi}$

The allowable shear stress is 17,170 psi. Refer also to Calculation #9.

**Calculation # 4 – Stresses in Frame Due To Lifting**

The frame may be lifted from the horizontal position (frame parallel to floor) into the vertical position.
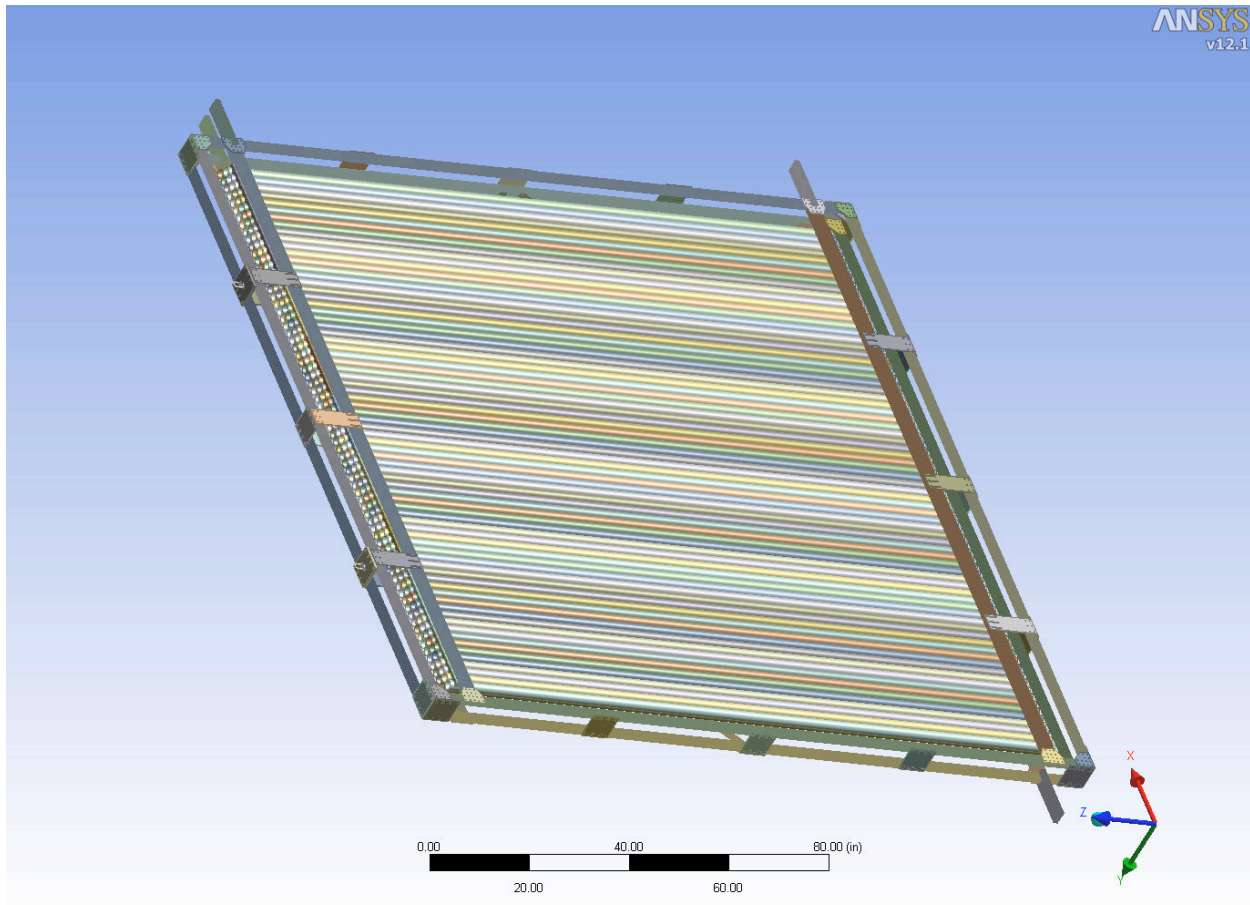
Frame in horizontal position (tube axes parallel to floor)

The frame would be supported along two opposite edges of the frame.  Total frame weight is estimated at 700 lb.  This will be a distributed load between the two supported ends.  Maximum bending moment will occur between the supported ends.

$M_{midspan} = wL^2/8$  or   FL/8

Where:

L=length of span

w = distributed load = 700 lb/152 in. = 4.6 lb/in.

F = total load = wL

$M_{midspan}$ = (700 lb)( 152 inches )/8 = 13,300 in-lb

Need to take credit for both top and bottom layers of 1020 structural members.  This will mean that shear must be transmitted effectively between top and bottom layers.  Check bending stress for

situation where top and bottom 1020 layers participate. Use parallel axis theorem to calculate net moment of inertia ($I_x = I_{xc} + Ad_1^2$). Refer to included vendor data attached.

$I_{total}$ = 2(0.0833 in.$^4$) + 2( 0.7914 in.$^2$)(2 in.)$^2$ = 6.5 in.$^4$

$\sigma_{max}$ = M c/I = (13,300 in-lb)(2.5in.)/6.5 in.$^4$ = 5,116 psi

The allowable tensile stress is 19,487 psi for the 6105-T5 1020 members. Consequently, the calculated stress is acceptable.

Maximum deflection is calculated as follows.

$Y_{max}$ =5wL$^4$/(384 EI)= 0.5 in.

E = 10,000,000 psi for aluminum

No credit is taken for the tubes. Actual deflection will be less than this.

Maximum shear load occurs at each supported end, and is equal to 700 lb/2. Shear will be carried on either side of the frame, so each side must carry 175 lb. Strap plates are 5.75 in. x 6.00 in. and are 0.188 thick. Shear stress is calculated as follows.

$A_{shear}$ = 6.00 in. x 0.188 in. = 1.13 in.$^2$

$\tau$ = V/A = 175 lb/1.13 in.$^2$ = 155 psi

The allowable shear stress in the plates is 12,247 psi.

Calculate stress in the screws which attach the strap plates to the 1020. Four of the five strap plates will be taken credit for. Four 0.25 inch diameter screws in each plate must react both the actual shear force (175 lb/8 screws = 22 lb) as well as the couple developed by 175 lb over a lever arm of 5 inches.

(175 lb)(5 in.) = 8(2.8 in.)$V_{couple}$ +8(2.0 in.) $V_{couple}$ (2.0 in./2.8 in.)

$V_{couple}$ = 26 lb

$V_{lateral\ load}$ =175 lb/8 screws = 22 lb

The angle between the vectors of the two shear force components listed above

$V_{total}$ = 26 lb + 22 lb = 48 lb

$\tau$ = $V_{total}$/$A_{0.25\ in.\ diam.\ screw}$ = 48 lb/0.0269 in.$^2$ = 1,784 psi

The allowable shear stress in the screws is 2,168 psi, per Calculation #9. The directions of the two shear forces are 45 degrees apart, which will lower the stress.

Frame in vertical position (tube axes perpendicular to floor)

Stresses in the frame are minimal in the vertical position. Loads are well distributed throughout frame, no significant bending moments occur, and stresses are primarily membrane through the frame members. Loads are well distributed from the lifting lug locations.

**Calculation # 5**

Calculate bending stress and shear stress for the situation where the frame is supported by a support that runs across the middle of the frame. In other words, frame is set down on a 4" X 4" wood member lying on the floor. The wood member runs across the frame mid-span perpendicular to the tube axis direction.
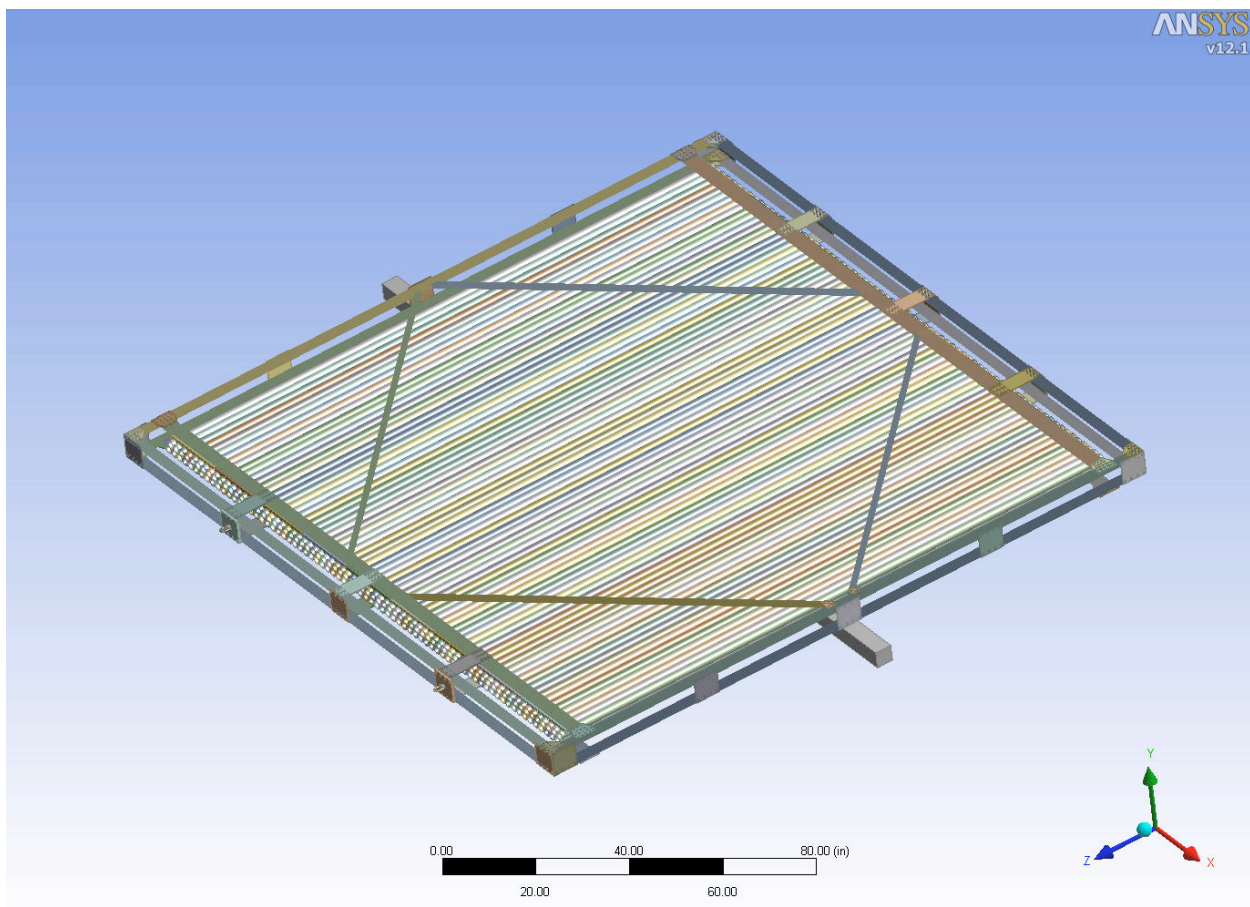


Attached 1020 information shows the moment of inertia about the weak axis of a 1020 member to be 0.0833 in.[4] The tubes are supported at the ends via the scalloped brackets. The bottom 1020 pieces (one on each side) will initially be considered to carry the load. Use the case of a cantilevered beam whose length is 76 inches. Point load is 700 lb/4 or 175 lb.

Moment $_{max}$ = (175 lb)(76in) = 13,300 in-lb

$\sigma_{max}$ = M c/I = (13,300 in-lb)(0.5in.)/0.0833 in.$^4$ = 79,832 psi

Stress is too high, as yield stress is 35 ksi for 6105-T5 aluminum.

Need to take credit for both top and bottom layers. This will mean that shear must be transmitted effectively between top and bottom layers. Check bending stress for situation where top and bottom 1020 layers participate. Use parallel axis theorem to calculate net moment of inertia ($I_x = I_{xc} + Ad_1^2$).

I $_{total}$ = 2(0.0833 in.$^4$ ) + 2( 0.7914 in.$^2$)(2 in.)$^2$ = 6.5 in.$^4$

$\sigma_{max}$ = M c/I = (13,300 in-lb)(2.5in.)/6.5 in.$^4$ = 5,115 psi

Bending stress is acceptable since the calculated stress is less than the 19,487 psi allowable tensile stress for the 1020 beams. Reaction load at ends is 175 lb, so shear force of 175 lb must be carried within the frame at the ends. Strap plates are 5.75 in. x 6.00 in. and are 0.188 thick. Shear area is

$A_{shear}$ = 6.00 in. x 0.188 in. = 1.13 in.$^2$

$\tau$ = V/A = 175 lb/1.13 in.$^2$ = 155 psi

The allowable shear stress for 6105-T5 is 12,247 psi. Accordingly, this calculated stress is acceptable.

Calculate stress in the screws which attach the strap plate to the 1020. Four of the five strap plates will be taken credit for. Four 0.25 inch diameter screws must react both the actual shear force as well as the couple developed by 175 lb over a lever arm of 5 inches.

(175lb)(5 in.) = 8(2.8 in.)$V_{couple}$ + 8(2.0 in.)$V_{couple}$ (2.0 in./2.8 in.)

$V_{couple}$ = 26 lb

$V_{lateral\ load}$ =175 lb/8 screws = 22 lb

$V_{total}$ = 26 lb + 22 lb = 48 lb

$\tau$ = $V_{total}/A_{0.25\ in.\ diam.\ screw}$ = 48 lb/0.0269 in.$^2$ = 1,784 psi

The fastening hardware is AISI 4037 quenched and tempered steel, according to the 80/20 vendor. The allowable fastener stress is 2,168 psi per Calculation #9. The directions of the two shear forces are 45 degrees apart, which will lower the stress.

**Calculation # 6**

This calculation is similar to Calculation #5 above, but the wood beam placed on the floor runs coincident with the tubes. It supports the frame in the middle, but 90 degrees to the wood floor

support in Calculation #5.  The frame is square and there are more support members running across the ends so stresses will be lower.
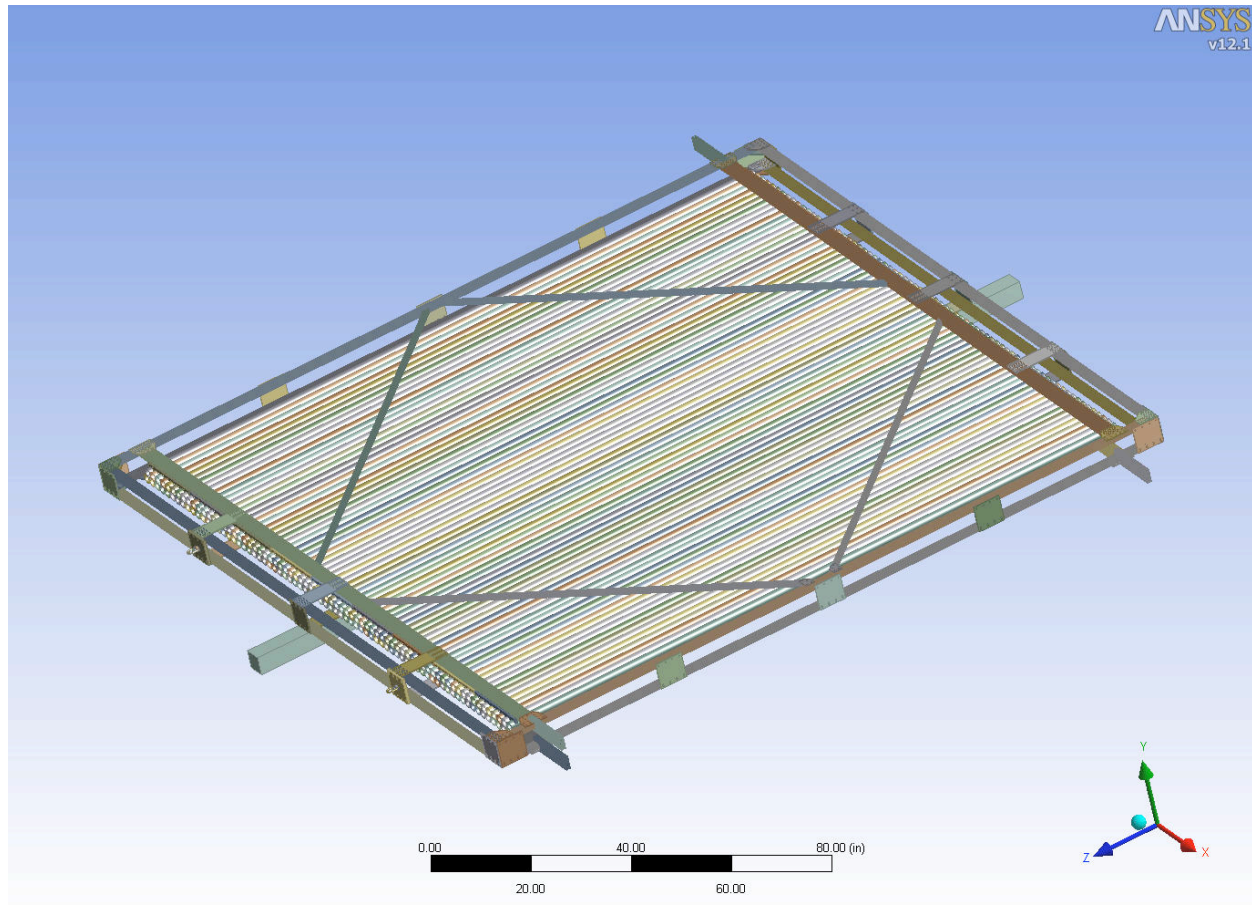


Moment$_{maximum}$ = 13,300 in-lb     (from above, as frame is square)

Frame has a lower layer and an upper layer.  Strap plates will connect the upper and lower layers, so that the upper and lower layers can be taken credit for in bending, as in Calculation #5.  There is a 1020 and 1030 piece on the bottom, and a 1020 and 1030 piece on top.  The effective I for these bottom and top layers is more than for Calculation #5.  The maximum moment and c are the same.  Thus bending stress will be lower.  Shear will be transmitted as in Calculation #5, so shear stress is acceptable.  Scalloped pieces were not taken credit for.  Also this case involves more of a distributed load along beam, versus a point load at the end for Calculation #5.

**Calculation # 7**

Check bending stress for bending about an axis that runs corner to corner. Frame laid down on floor onto wood beam from Calculation #5 and #6, wherein beam runs from frame corner to frame corner. Use parallel axis theorem again, and use the plate thickness at the corners.
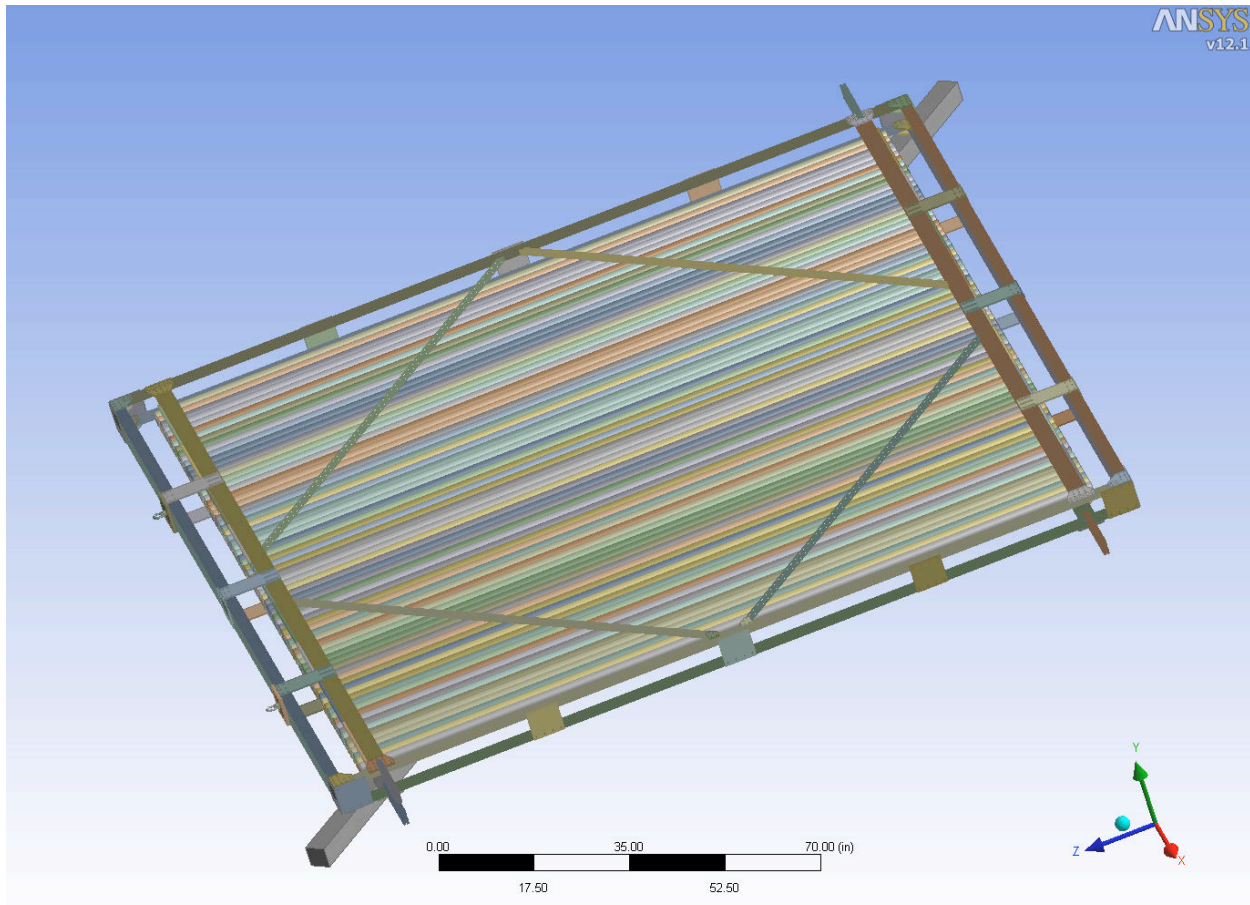


Calculate maximum moment. The area on either side of the wood beam is triangular, with the center of mass 1/3 of the way out from the diagonal bending axis, or 108.2 in./3 or 36 inches.

$Moment_{maximum}$ = (350 lb)(36 in.) = 12,600 in.-lb

Use parallel axis theorem to calculate net moment of inertia ($I_x = I_{xc} + Ad_1^2$) for the brackets at the frame corners.

$I_{total for brackets at corners}$ = ~0 in.$^4$ + 8(0.188 in.)( 4.0 in.)(2.5 in.)$^2$ = 37.6 in.$^4$

$\sigma_{max}$ = M c/I = (12,600 in-lb)(2.5in.)/37.6 in.$^4$ = 838 psi

Bracket material is 6105-T5 material with an allowable shear stress of 12,247 psi. Calculated stress is acceptable.

Check shear stress in screws that attach the eight plates.

Moment$_{maximum}$ = (5in.)(4 plates)F$_{plate}$      (summing moments about lower frame surface at brackets)

F$_{plate}$ =630 lb.

Each plate has at least 12 screws.  Each side of the plate has six screws.  Force per screw is then 630 lb/6 or 105 lb.  Screws are ¼"-20, with a shear area of 0.0269 in.$^2$  The shear stress in the screw is calculated as follows.

$\tau$ = V$_{total}$/A$_{0.25\ in.\ diam.\ screw}$ = 105 lb/0.0269 in.$^2$ = 3,904 psi

The "failure stress" calculated in Calculation #9 is 6,505 psi.  The situation described in this calculation is not a standard service condition, but rather an abnormal event.  Additionally, no credit was taken for the diagonals participation in reacting the moment, nor for the vertical (web type) strapping plates at the corners, nor the inherent strength of the tube type array within the frame.  Taking credit for these effects would reduce stress significantly.  Based upon the aforementioned, the situation is judged to be acceptable.


**Calculation # 8**

The following calculation will consider frame skewing (i.e. frame tendency to go from a square to a parallelogram shape).  This deformation mode is what the four diagonal members are used to prevent.  This scenario would cover an event where the frame is lowered onto one corner while providing lateral restraint.  The following will calculate the stress in the diagonal, the attachment plate and the screws.


As the frame tries to skew, two of the four top diagonals will be placed in tension, and two in compression.  The same holds true for the bottom layer.  Only the diagonals placed in tension will be taken credit for since the compressed two could bow.   Refer to Sketch 1 below.

SKETCH 1
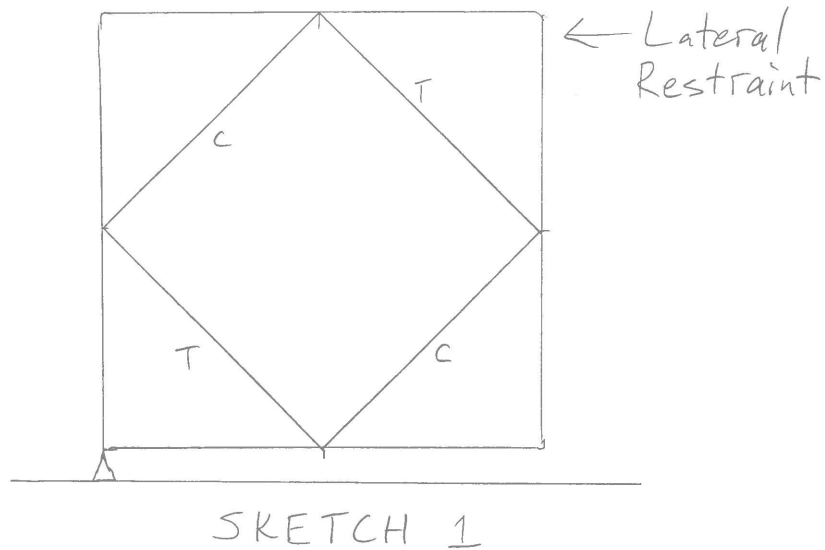
The total frame weight is 700 lb. Frame corner connections will be assume to be pinned, with all of the support provided by the diagonals. Half of the load carried by the bottom layer of four diagonals , and half carried by the top layer. Each top layer tensile diagonal then carries 175 lb (700 lb /2 layers is 350 lb per layer, then divided by two for two tensile diagonals is 175 lb per tensile diagonal) . Summing moments about pivot 1 in Sketch 2, $F_{cross\ piece,\ frame}$ is 88 lb. Summing forces about Pivot 2 in Sketch 3, the force in the diagonal is 250 lb. The diagonal is made from 1010 with a cross sectional area of 0.4379 in.$^2$

175 lb

88 lb ←  Pivot 1                         Pivot 2

88 lb →

175 lb          SKETCH 2

248 lb

Pivot 2

175 lb ←

→ 88 lb

SKETCH 3
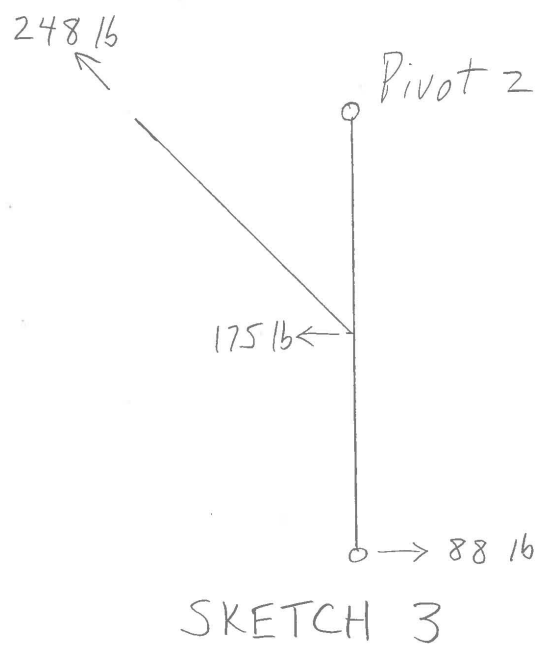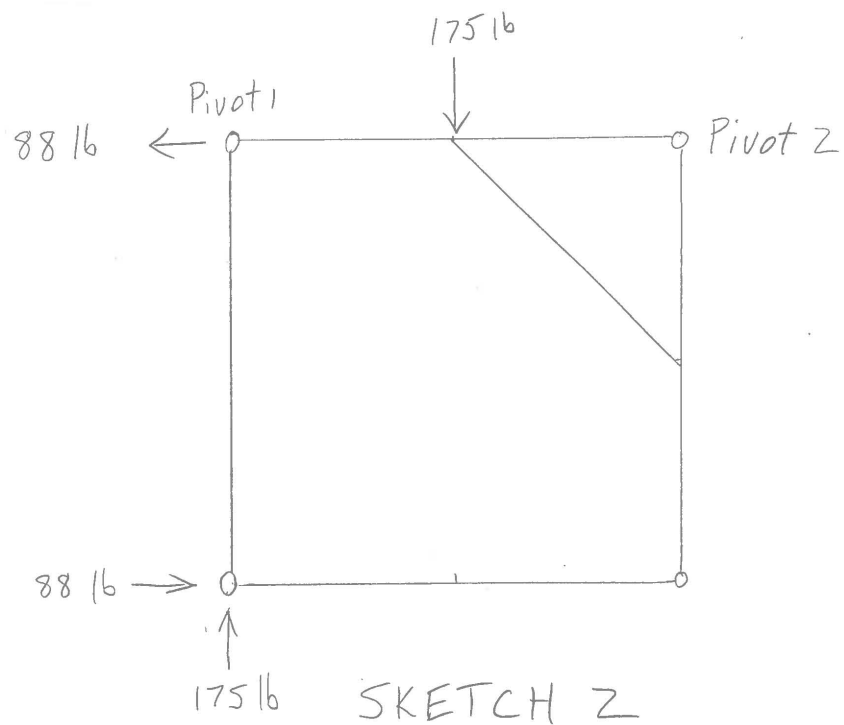
$\sigma_{brace} = F/A = 250$ lb$/0.4379$ in.$^2 = 571$ psi

The bracket attaching the diagonal is 0.188 in. thick with a min. width of 2 in.

$A_{bracket, \text{cross section}} = (0.188 \text{ in.})(2 \text{ in.}) = 0.376 \text{ in.}^2$

$\sigma_{bracket} = F/A = 250$ lb$/0.376$ in.$^2 = 665$ psi

The brace and bracket stresses calculated above are acceptable as they are below the 19,487 psi allowable stress.

Bracket is attached with two screws on either side. Shear stress in screws is calculated as follows.

$A_{shear, 0.25 \text{ in. diam.}} = 0.0269 \text{ in.}^2$

$\tau = V_{total}/2A_{0.25 \text{ in. diam. screw}} = 250$ lb$/[2(0.0269 \text{ in.}^2)] = 4{,}647$ psi

The "failure stress" calculated in Calculation #9 is 6,505 psi. The situation described in this calculation is not a standard service condition, but rather an event which would constitute "rough handling". Additionally, no credit was taken for the strapping plates at the corners, nor the inherent strength of the tube type array within the frame. Taking credit for these effects would reduce stress significantly. Based upon the aforementioned, the situation is judged to be acceptable.

The same results hold for the other top layer diagonal, as each is assumed to carry 175 lb.

**Calculation # 9**

The strength of the fastened connection between joining plates and the 1020 or 1030 members will be evaluated herein. The fasteners which attach the joining plates to the 1020 or 1030 members are ¼"-20 screws. According to the manufacturer, these screws are made from AISI 4037 quenched and tempered steel. These screws go through the joining plates and are threaded into an "economy nut" within the 1020 or 1030 channel. It is difficult to analyze the shear strength (load across fastener) or tensile strength (load along fastener axis) of this connection with respect to the nut pulling out of the extruded part. Optimistically one would consider the shear strength or tensile strength of the screw and use a large allowable shear force or tensile force. The 80/20 manufacturer recommends an allowable shear load of 175 lb per the attached page 155 of their catalog. The shear area of a ¼"-20 screw is 0.0269 in.$^2$. The allowable shear stress could be calculated using the vendor load as,

$\tau_{allowable} = V_{\text{vendor allowable}} / A_{shear} = 175$ lb$/0.0269$ in.$^2 = 6{,}505$ psi

This pertains to shear loading of the screw. A factor of safety of three will be utilized, so that the maximum allowable shear stress is 6,505 psi/3 or 2,168 psi. This stress will be treated as the maximum allowable shear stress in the ¼"-20 screws for the frame analysis. This stress will also be treated as the maximum allowable tensile stress for the screws for the frame analysis.

## Why Do We Use 6105-T5 Aluminum Alloy?

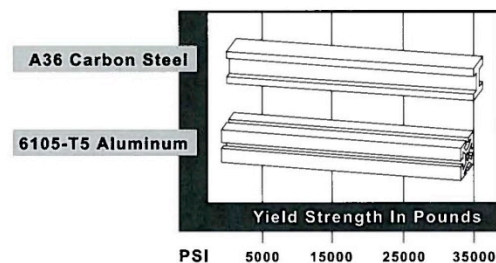| Aluminum Profile Alloys: Number and Characteristics | Tensile Strength - ksi* | | | |
|---|---|---|---|---|
| | Ultimate | | Yield | |
| | minimum | maximum | minimum | maximum |
| 6105-T5 (80/20's Alloy) | 38.00 | ·· | 35.00 | ·· |
| 6063-T6 | 30.00 | ·· | 25.00 | ·· |

*Figures based on material thickness of 0.125 to 1.00"
From The Aluminum Extrusion Manual, published by The Aluminum Association and the Aluminum Extruders Council.

All of 80/20's T-slotted profiles feature the 6105-T5 alloy. An aluminum extrusion alloy is a mixed metal that includes other elements such as copper, magnesium, iron, silicon or zinc. Certain properties such as strength, machinability and corrosion resistance are influenced by the choice of alloy and temper. **Alloy 6105 with a T5 temper, chosen by 80/20, has better machinability and strength than 6063-T6.**

6105    T5
↑    ↑
**Alloy  Temper**

## Material Strength Specifications

A36 Carbon Steel

6105-T5 Aluminum

Yield Strength In Pounds

PSI    5000    15000    25000    35000

### Minimum Yield Strength In Pounds

- 80/20®'s 6105-T5 alloy yield strength of 35,000 psi compares to A36 carbon steel's yield strength of 36,000 psi.

- Volume for volume, aluminum weighs about 1/3 as much as iron, steel, copper, or brass.

**Deflection Calculator X** ™
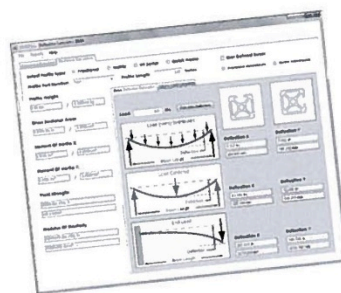
**Download 80/20®'s Deflection CalculatorX™, the profile strength calculator, at www.8020.net/Design-Tools-1.asp**

# Fractional

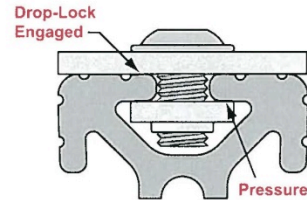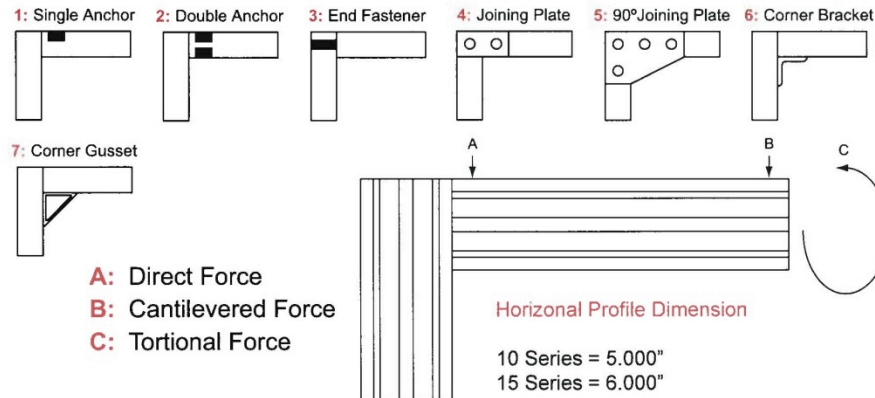## Torque Specifications

- **See table below for the amount of torque in foot-lbs. required to activate the 2° drop-lock feature for T-slotted profiles**
- **Nut and bolt combination is pre-loaded when tightened to the minimum torque rating**
- **When properly tightened, fasteners will not loosen even under heavy vibration**

Drop-Lock Engaged

Pressure

| Part Number | Fastener Description | Tested Profile | Minimum Ft-lbs. Torque | Maximum Ft-lbs. Torque |
|---|---|---|---|---|
| 3320 | 5/16-18 x 11/16 Flanged BHSCS & Economy T-Nut | 1515 | 10.00 | 15.00 |
| 3325 | 5/16-18 x 3/4 Economy T-Slot Stud, Washer & Hex Nut | 1515 | 30.00 | 40.00 |
| 3360 | 15 Series Anchor Fastener Assembly | 1515-Lite | 10.00 | 28.00 |
| 3380 | 15 Series End Fastener Assembly | 1515-Lite | 10.00 | 22.00 |
| 3321 | 1/4-20 x 1/2 Flanged BHSCS & Economy T-Nut | 1010 | 4.00 | 6.00 |
| 3395 | 10 Series Anchor Fastener Assembly | 1010 | 3.00 | 17.00 |
| 3381 | 10 Series End Fastener Assembly | 1010 | 4.00 | 17.00 |

## Fastener Application Tests

**1:** Single Anchor   **2:** Double Anchor   **3:** End Fastener   **4:** Joining Plate   **5:** 90°Joining Plate   **6:** Corner Bracket

**7:** Corner Gusset

**A:** Direct Force
**B:** Cantilevered Force
**C:** Tortional Force

Horizonal Profile Dimension
10 Series = 5.000"
15 Series = 6.000"

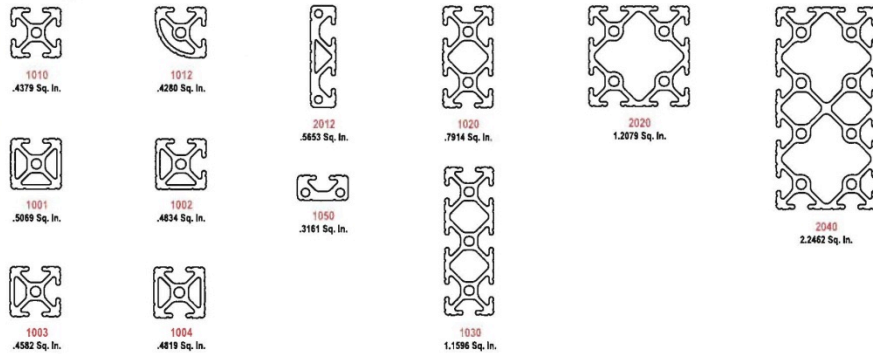| Fastener | 1010 Profile | | | 1515-Lite Profile | | | 1515 Profile | | |
|---|---|---|---|---|---|---|---|---|---|
| | A (lbs.) | B (lbs.) | C (Inch-lbs.) | A (lbs.) | B (lbs.) | C (Inch-lbs.) | A (lbs.) | B (lbs.) | C (Inch-lbs.) |
| 1 | 500 | 250 | 180 | 950 | 625 | 540 | 950 | 1,000 | 700 |
| 2 | 900 | 250 | 260 | 1,200 | 700 | 1,150 | 1,200 | 1,200 | 2,000 |
| 3 | 450 | 200 | 325 | 1,000 | 500 | 680 | 1,000 | 820 | 1,150 |
| 4 | 175 | 50 | 400 | 225 | 200 | 1,000 | 225 | 200 | 1,100 |
| 5 | 175 | 50 | 500 | 250 | 200 | 1,120 | 250 | 200 | 1,260 |
| 6 | 325 | 75 | 180 | 375 | 225 | 500 | 575 | 225 | 500 |
| 7 | 325 | 220 | 260 | 375 | 750 | 500 | 575 | 750 | 500 |

**Note:** Plates, brackets and gussets were attached with 80/20® recommended bolt kits. Fasteners were tightened according to 80/20® torque specifications found at the top of the page.

Test results reflect the connection failure point. Loads at or above these points are not recommended.

**Phone: 260-248-8030   •   Fax: 260-248-8029   •   www.8020.net**

# 80/20® Inc.
*The Industrial Erector Set*
**THE STANDARD**

## 10 Series Profile Material Specifications



1010 .4379 Sq. In.  
1012 .4280 Sq. In.  
2012 .5653 Sq. In.  
1020 .7914 Sq. In.  
2020 1.2079 Sq. In.  
2040 2.2462 Sq. In.  
1001 .5069 Sq. In.  
1002 .4634 Sq. In.  
1050 .3161 Sq. In.  
1003 .4582 Sq. In.  
1004 .4819 Sq. In.  
1030 1.1596 Sq. In.

## Compatibility Code*: 6-10

| Part No. | 1010 | 1001 | 1002 | 1003 | 1004 | 1012 |
|---|---|---|---|---|---|---|
| Material | 6105-T5 Aluminum | | | | | |
| Finish | Clear Anodize #204-R1 | | | | | |
| Weight Per Foot | .5097 Lbs. | .5900 Lbs. | .5627 Lbs. | .5333 Lbs. | .5609 Lbs. | .4982 Lbs. |
| Stock Length ** | 97", 145", 242" | 145" or 242" | 145" or 242" | 145" or 242" | 145" or 242" | 145" or 242" |
| Moment of Inertia | IX=.0442$^4$ IY=.0442$^4$ | IX=.0542$^4$ IY=.0493$^4$ | IX=.0492$^4$ IY=.0492$^4$ | IX=.0491$^4$ IY=.0441$^4$ | IX=.0541$^4$ IY=.0443$^4$ | IX=.0400$^4$ IY=.0400$^4$ |
| Estimated Area | .4379 Sq. In. | .5069 Sq. In. | .4834 Sq. In. | .4582 Sq. In. | .4819 Sq. In. | .4280 Sq. In. |
| Modulus of Elasticity | 10,200,000 Lbs./Sq. In. | | | | | |

| Part No. | 1050 | 2012 | 1020 | 1030 | 2020 | 2040 |
|---|---|---|---|---|---|---|
| Material | 6105-T5 Aluminum | | | | | |
| Finish | Clear Anodize #204-R1 | | | | | |
| Weight Per Foot | .3679 Lbs. | .6580 Lbs. | .9212 Lbs. | 1.3498 Lbs. | 1.4060 Lbs. | 2.6146 Lbs. |
| Stock Length ** | 145" | 145" | 97", 145", 242" | 145" or 242" | 145" or 242" | 145" or 242" |
| Moment of Inertia | IX=.0074$^4$ IY=.0323$^4$ | IX=.2253$^4$ IY=.0146$^4$ | IX=.3078$^4$ IY=.0833$^4$ | IX=.9711$^4$ IY=.1238$^4$ | IX=.5509$^4$ IY=.5509$^4$ | IX=3.5168$^4$ IY=1.0513$^4$ |
| Estimated Area | .3161 Sq. In. | .5653 Sq. In. | .7914 Sq. In. | 1.1596 Sq. In. | 1.2079 Sq. In. | 2.2462 Sq. In. |
| Modulus of Elasticity | 10,200,000 Lbs./Sq. In. | | | | | |

* See Compatibility Code information on page 152.
** For profile lengths other than stock length refer to page 563 for profile cut to length services.

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